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PAVLOVIAN CONDITIONING OF SHOCK-ELICITED AGGRESSION: A DISCRIMINATION PROCEDURE[1]

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Two auditory stimuli, separated by a fixed intertrial interval, were alternately presented to two rats in a closed environment. The positive conditioned stimulus (CS+) terminated with the offset of a 2-mA, 0.75-sec shock. The negative conditioned stimulus (CS−) terminated without shock. The incidence of the "stereotyped fighting posture" was recorded during the CS+, the CS−, the intertrial interval, and shock. The results showed an increase in the percentage of conditioned responses during the CS+, and a decrease during both the CS− and the intertrial interval, when the duration of the conditioned stimuli and the intertrial interval was 16 sec. Appropriate changes in the incidence of aggression during the two stimuli were obtained following the reversal of the stimulus functions. During the acquisition and reversal phases there was a between-session decrement and a within-session improvement in the incidence of aggression during the CS+, defined as warm-up. The presentation of free shocks before the conditioning sessions was effective in reducing the warm-up only when the interval between shocks was 64 sec. These data were interpreted as demonstrating classical conditioning of shock-elicited aggression, with little chance of non-associative factors contributing to the measurement of the conditioned response.

The delivery of brief shocks to paired rats in a closed environment evokes an intense form of aggression. Typically, the animals face one another in an upright posture with head thrust forward, mouth open and paws extended, and from this position they strike vigorously with paws and teeth (O'Kelley and Steckle, 1939; Daniel, 1943; Ulrich and Azrin, 1962). The purpose of the present investigation was to study Pavlovian conditioning of this "stereotyped fighting posture" using a discrimination procedure.

The current status of the research involving Pavlovian conditioning of shock-elicited aggression in rats provides some evidence for successful conditioning (Vernon and Ulrich, 1966; Creer, Hitzing, and Schaeffer, 1966; Farris, Gideon, and Ulrich, 1968). A delayed conditioning procedure was used in all of the studies, consisting of a 1-sec conditioned stimulus (CS) and 0.5-sec unconditioned stimulus (UCS), with a 10-sec intertrial interval. The UCS was presented 0.5 sec after the onset of the CS, and then both stimuli terminated simultaneously. Due to the brief CS duration used, a CS-alone test trial was scheduled after every block of 10 trials to assess the course of conditioning (Vernon and Ulrich, 1966; Creer *et al.*, 1966; Farris *et al.*, 1968). The use of the test trial procedure, however, often markedly alters the course of conditioning and does not permit the assessment of the continuous growth of the acquisition process (Gormezano, 1966). In addition, the control procedure used for sensitization and pseudoconditioning in these studies does not provide unequivocal evidence of classical conditioning, since the temporal distribution of the CS and UCS during the control sessions was not identical to the distribution used during conditioning. Specifically, Vernon and Ulrich (1966) presented 1000 unpaired shocks during one session at 10-sec intervals followed by CS-alone trials to test for pseudoconditioning. During conditioning, however, only 182 shocks were presented per session.

The design of the present study involved a Pavlovian discrimination procedure and a discrimination reversal, as a control for pseudoconditioning and sensitization (Gormezano, 1966). In addition, a longer CS duration than previously used was employed in the present study to provide an opportunity to

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record anticipatory conditioned responses during the CS and before the onset of the UCS.

METHOD

Subjects

Thirty-two male albino rats, 120 days old at the beginning of experimentation, were divided into 16 pairs that remained intact for the duration of the experiment. Each experimental animal was housed separately. Food and water were available at all times except during experimental sessions.

Apparatus

An aluminum response chamber, measuring 8 by 10 by 12 in. (20 by 25 by 30 cm), with a Plexiglas front wall, was enclosed in a sound-attenuated shell fitted with an air blower to provide ventilation. A viewing window, 6 by 4 in. (15 by 10 cm), was mounted on one wall of the shell, and a 15-w bulb was used inside the enclosure for general illumination. The floor of the chamber was constructed of stainless steel rods with a 0.5 in. (13 mm) diameter and spaced 1/8 in. (3 mm) apart. The 2-mA, 0.75-sec shock was delivered by a Grason-Stadler shock generator, type E1064GS.

A 2800-Hz tone at 87 db was provided by a Sonalert, Model 2C628 (P. R. Mallory and Co.). The click stimulus was provided by a click generator from BRS-Foringer. The click rate was measured at 7 per sec, and the intensity at 75 db. The sound intensity of both stimuli was measured on the A scale of a type 2203 sound-level meter (Bruel and Kjaer, Co.).

The incidence of aggression was measured by human observers according to the criterion described in the procedure section. The responses were recorded by the manual closure of a microwsitch on one of four electrical impulse counters, automatically programmed to coincide with the positive and negative conditioned stimuli (CS+, CS−), intertrial interval, and shock. The experimental procedure was arranged by appropriate timers and relay circuitry.

Procedure

Response definition. The aggression response was recorded by a human observer when the animals assumed the "stereotyped fighting posture", which is characterized by the animals standing in an upright position, facing one another with head thrust forward, mouth open, and paws extended. This position is so vastly different from the other observed forms of behavior that there was little difficulty in distinguishing the presence of a response. The presence of this fighting posture during the CS+, CS−, the intertrial interval, or shock was recorded only once during any given trial. Other response topographies, such as strikes by the paws or teeth, which often occurred during CS+ trials in addition to the posture, were not recorded as additional responses. If the animals were already in the stereotyped fighting posture at the termination of the CS+ when the shock was presented, an aggression response was recorded if and only if three or more rapid strikes with the paws or biting occurred. It is important to note that the animals never maintained the posture for extended periods of time. Therefore, all the responses during the CS+ primarily represent the presence of the stereotyped posture, although strikes by paws and teeth also may have occurred in addition to the posture.

General design. Two auditory stimuli, a tone and a clicker, were alternately presented for a fixed duration and separated by a constant intertrial interval. One stimulus, the CS+, terminated coincidentally with the offset of a 2-mA, 0.75-sec shock. In Exp. I only, a 0.5-sec shock duration was used with Pair 2. The other stimulus, the CS−, had the same duration as the CS+, but terminated without shock. Each daily experimental session was terminated after the presentation of 50 CS-shock pairings.

Experiment I. Initially six pairs of animals were exposed to different durations of the CS+, CS−, intertrial interval. The specific conditions for each pair of animals are presented in Table I.

Experiment II. Little or no conditioning was obtained in Exp. I except for Pair 6 with a CS duration and intertrial interval of 16 sec. Therefore, in Exp II, Pair 6 was continued on the 16-sec CS, 16-sec intertrial interval schedule, Pairs 1 and 3 were then changed to this schedule, and two additional pairs, 7 and 8, were added with the same 16-sec CS, 16-sec intertrial interval schedule. The specific procedures for these animals are presented in Table 2. After reaching criterion of 35% or more aggression responses during CS+ per session for six consecutive sessions, the functions

Table I

Experimental procedures for pairs 1 – 6: for Exp. I showing the duration of the CS+ and intertrial interval in seconds, type of CS+ stimulus, number of sessions and median percentage of fights during CS+ for the last five sessions.

Pair	CS± Duration	Intertrial Interval Duration	CS+	Sessions	Mdn. Fights
1	4	10	clicker	22	6
2	1	10	clicker	20	6
3	4	16	tone	21	2
4	16	4	tone	20	4
5	4	4	tone	20	2
6	16	16	clicker	20	50

of the two stimuli were reversed. The stimulus that served as the CS+ was scheduled as the CS– and the stimulus that served as CS– was scheduled as CS+.

Table II

Experimental procedures for Exp. II showing the type of CS+ stimulus, number of sessions in acquisition, number of sessions in reversal and the Mdn. number of fights during the CS+ and CS– during the last five sessions of acquisition.

Pair	CS+	Acquisition	Reversal	Mdn. CS+	Mdn. CS–
1	clicker	21	15	42	2
3	tone	20	–	20	8
6	clicker	35	18	50	0
7	tone	37	13	38	0
8	tone	26	16	36	6

Experiment III. The warm-up effect, characterized by a between-session decrement and a within-session improvement, was studied by the delivery of 50 free shocks at different intervals before conditioning. This design was used for two reasons. First, the apparent conditioning reported in Exp. II may have reflected a sensitization process that should occur regardless of the between-shock interval used for the free shocks. Secondly, the warm-up phenomenon is of a more general interest since it is reported in most studies of avoidance, and the free-shock procedure has been effective in reducing warm-up in avoidance. A series of 50 free shocks without the conditioned stimuli was scheduled before the conditioning sessions for Pairs 1 and 6; the number of aggression responses was then measured during 10 trials with the usual 16-sec CS, 16-sec intertrial interval schedule used in conditioning. The effect of the free shocks was tested for five sessions at each of five intershock intervals presented in the following sequence: 64, 4, 8, 16, and 32 sec. Before proceeding from one intershock interval to the next, the animals were exposed to the 16-sec CS, 16-sec intertrial interval schedule until a criterion of 35% or more responses during CS+ was obtained for two consecutive sessions. Note that the 64-sec intershock interval was identical to the interval used in conditioning, since two 16-sec CS presentations of two 16-sec intertrial intervals occurred between each shock.

Pair 3 was not exposed to this procedure because a substantial degree of conditioning was not obtained with these animals; nor were data obtained from Pair 8, because their behavior declined during the reversal procedure. Data were obtained for only two free-shock frequencies with Pair 7, after which the baseline could not be reestablished. These data are not reported.

Table III

Experimental procedure for Pairs 9 through 16. The table shows the duration of the CS+ and CS– in seconds, the duration of the intertrial interval in seconds, the type of CS+ used, the number of sessions and the Mdn. percent fights during the CS+ for the last five sessions.

Pair #	CS± Duration	Intertrial Interval Duration	CS+	Sessions	Mdn. Fights
9	8	24	tone	15	0
10	8	24	clicker	20	0
11	8	24	clicker	20	6
12	24	8	tone	20	0
13	24	8	clicker	20	0
14	24	8	clicker	20	0
15	4	28	clicker	20	0
16	4	28	tone	20	0

Experiment IV. The results of Exp. II and III suggest that the delivery of shocks at 64-sec intervals was one of the important variables for conditioning. The duration of the conditioned stimuli, CS+ and CS–, was varied in this experiment, but the 64-sec intershock interval was maintained. The temporal variables are presented in Table 3 for the eight pairs of animals.

RESULTS

Experiment I

The percentage of fights during CS+, CS−, the intertrial interval, and shock were calculated for each session. The median percentage of responses during the CS+ for the last five sessions is presented in the last column of Table 1 for each pair of animals, numbers 1 through 6. Clearly, the only appreciable conditioning was obtained with Pair 6, which had been exposed to the 16-sec CS, 16-sec intertrial interval schedule.

Experiment II

The percentage of fights per session during each stimulus, intertrial interval and shock, are presented as a function of sessions in Fig. 1 and 2. These data[2] were recorded from Pairs 1 and 6 and are presented here as representative for Pairs 1, 6, 7, and 8. Pair 3, however, failed to show a substantial degree of conditioning.

[2]Figures showing data from the other animal pairs in this experiment may be obtained from the author.

The data presented in Fig. 1 for Pair 1 show little or no conditioning with a 4-sec CS and a 10-sec intertrial interval after 23 sessions. There was a rapid increase in the percentage of conditioned responses after the 16-sec CS, 16-sec intertrial interval schedule was introduced. After the reversal of the two stimuli, there was a rapid change in response distribution, with an increase in response during the new CS+ and a decrease during the new CS−. There was no general disruption of the discrimination in terms of increases in the responses during the intertrial interval during the reversal phase.

The data presented in Fig. 2 are for Pair 6. In general, these data indicate that the percentage of fights increased during CS+, and decreased during both the CS− and the intertrial interval as conditioning progressed. After the reversal there was an increase in fights during the new CS+ and a decrease during the new CS−.

It may be noted in Fig. 1 and 2 that the percentage of fights during CS+ seldom exceeded 50%. While this percentage of fights per session may appear low, suggesting a lack of con-

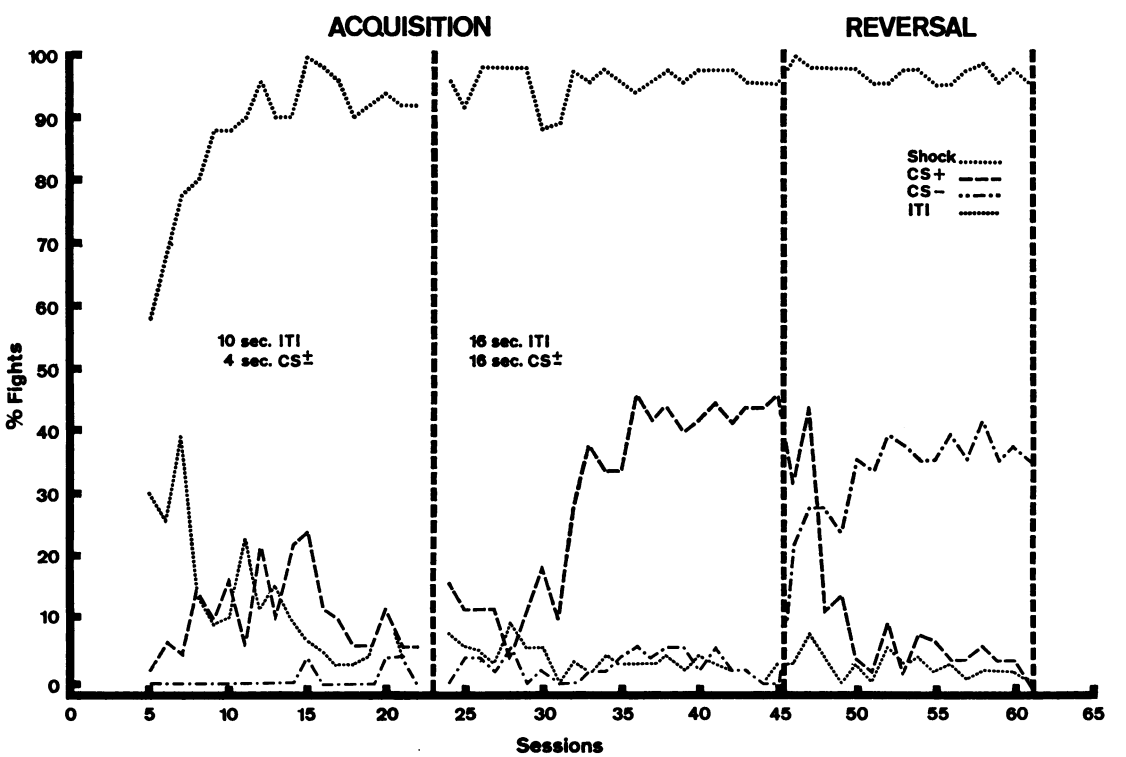

Fig. 1. Percentage of fights during CS+, CS−, the intertrial interval and to shock as a function of sessions during acquisition and reversal phases. No data were recorded for Sessions 1 to 4.

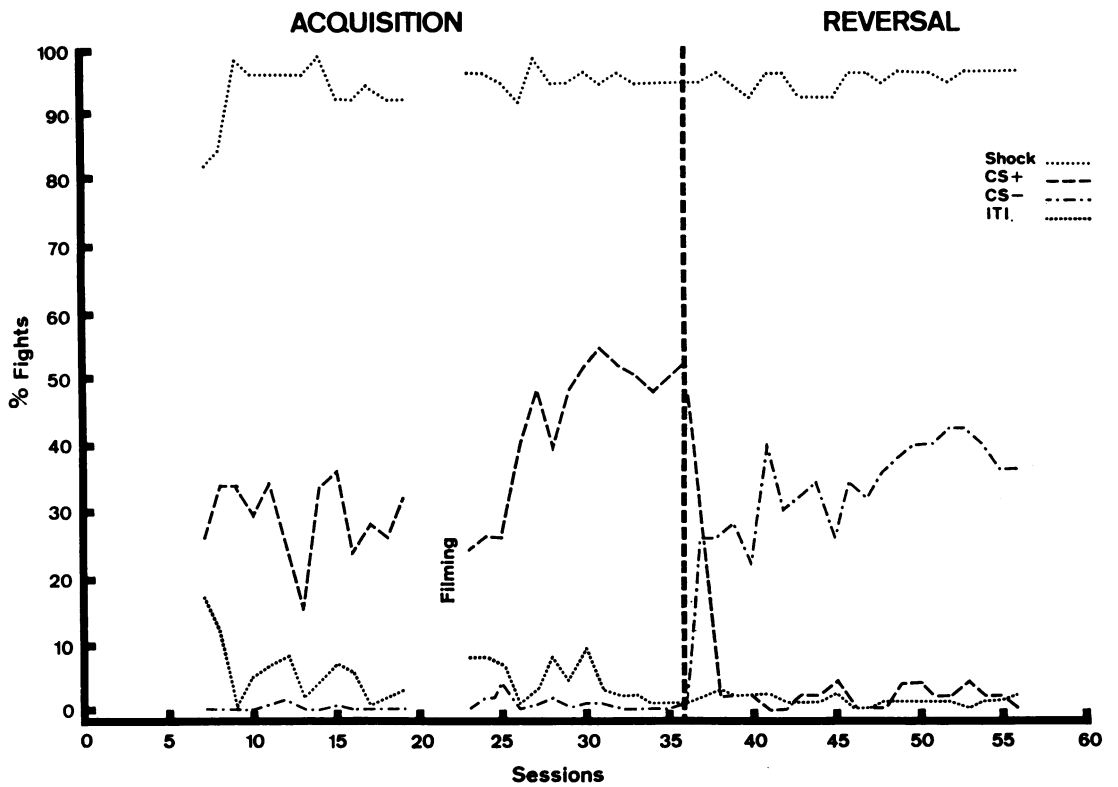

Fig. 2. Percentage of fights during CS+, CS−, the intertrial interval and to shock as a function of sessions during the acquisition and reversal phases. Data were not recorded during the period in which films were taken, although the animals were exposed to the regular conditioning program. No data were recorded for Sessions 1-6.

ditioning, there was a change in the percentage of fights during the CS+ within each session. The percentage of fights during CS+ as a function of 10 trial blocks is presented in Fig. 3 for Pair 6. These data were taken from six sessions during acquisition and three sessions during the reversal procedure. These data[2] are typical of Pairs 1, 6, 7, and 8 and indicate a general increase in the percentage of fights during CS+ as conditioning progressed and a within-session improvement during each session. This between-session decrement and within-session improvement in the percentage of fights during CS+ is defined as warm-up. For the last 10 trials during each of the later conditioning sessions, the percentage of fights during CS+ seldom fell below 80%.

Experiment III

As indicated in the procedure section, Exp. III was designed to explore the effects of free shock on the warm-up phenomenon shown in Fig. 3. The median and mean percentage of fights during the first 10 CS+ trials for all sessions of conditioning and reversal, and from the five sessions after administration of free shock at each free-shock interval were calculated for Pairs 1 and 6. Representative data[2] are presented in histogram form in Fig. 4 for Pair 6 only.

The figure shows a low mean percentage of conditioned responses during CS+ for the first 10 trials for all sessions during the acquisition and reversal phases. The administration of free shock before the conditioning procedure produced a substantial increase in the mean percentage of conditioned responses, only when free shock was delivered at 64-sec intervals.

Experiment IV

As indicated in the procedure section, this experiment was designed to determine the effect of varying CS duration, while maintaining the 64-sec intershock interval. The median percentage of fights during CS+ for the last five sessions for each pair are presented in Table III. All of the medians are at zero except

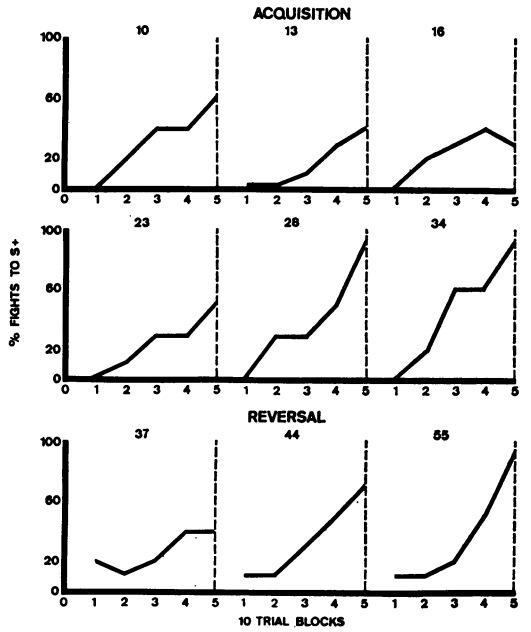

Fig. 3. Percentage of fights during the CS+ as a function of 10 trial blocks. Data represent six sessions during acquisition and three sessions during the reversal phase for Pair 6.

for Pair 11, and even this value, 6%, is not indicative of successful conditioning.

DISCUSSION

These data, presented in terms of conditioned response anticipatory to the UCS, provide evidence of classical conditioning of shock-elicited aggression. The discrimination procedure used is considered by many investigators as an appropriate control for non-associative factors that might contribute to the measurement of conditioned responses (Gormezano, 1966; Zeaman and Smith, 1965, Thompson and Sturm, 1965). The fact that the percentage of responses increased during the CS+ and decreased during the CS− strongly argues against these non-associative factors either in terms of pseudoconditioning or sensitization. The successful reversal of the discrimination further indicates that conditioning was independent of the specific stimulus used as the CS+.

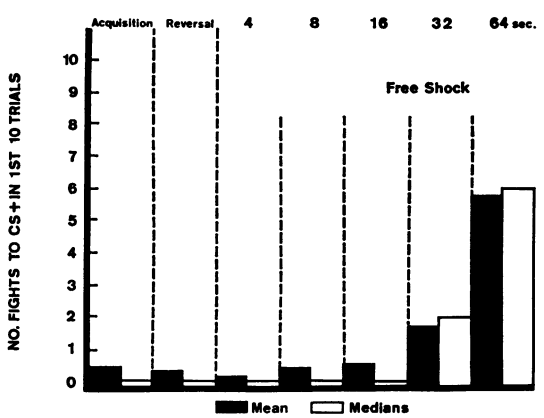

Fig. 4. The mean number of fights during the first 10 trials of each session for all sessions in acquisition, reversal, and the five sessions after each exposure to free shock for Pair 6.

Other writers (Rescorla, 1967) have criticized the discrimination procedure as a control for possible non-associative factors. Specifically, the present study could be criticized in terms of possible sensitization because the temporal relationship among the CS+, CS−, and the shock was held constant. There are three forms that this criticism might take. First, sensitization might have occurred as a result of the delivery of a fixed number of shocks only. If this were true, however, one would expect no differential effect of free-shock intervals upon warm-up as was reported in Exp. III. In that study, the same number of shocks was delivered at each interval, but only when the free shocks were delivered every 64 sec was there an increase in responses during the CS+.

Secondly, a more specific type of sensitization might have occurred which was dependent upon shocks being delivered at a specific interval. Indeed, the fact that the warm-up was attenuated when free shock was delivered at 64-sec intervals supports this conclusion. If this were true, however, one would expect no difference in the number of responses during the CS+ comparing the groups reported in Exp. IV and the successful conditioning obtained with the four groups with a 16-sec CS, 16-sec intertrial interval schedule in Exp. II, since shock was presented every 64 sec for all groups in both experiments.

Thirdly, sensitization may have been even more specific in that shocks presented every 64 sec set the stage for a response to occur during a stimulus presented 48 sec after the shock, as was possible only in the 16-sec CS, 16-sec intertrial interval schedule. If this were true, however, one would predict a very rapid decrease in responses during the original CS+ during reversal. During this procedure, the

original CS+ stimulus occurred in a very poor temporal relationship to the shock for possible sensitization according to this criticism and thus it should no longer produce a response. The reversal data in both Fig. 1 and 2, and in particular in Fig. 1, shows a gradual decrease in responses over three or more sessions during the original CS+ stimulus and not the rapid decrease that would be expected within a single session if the recorded responses represented sensitization only.

The attenuation of the warm-up effect by the delivery of shocks before the experimental session in Exp. III is also of interest as it relates to studies of avoidance behavior. Hoffman (1966) reported successful reduction of warm-up in a discriminated avoidance study by the presentation of massed free shocks before the experimental session. These data were interpreted as indicating that avoidance behavior was motivated in part by a general emotionality resulting from the presentation of shock. If one assumed that this emotionality would result from the delivery of shock over a wide range of intershock intervals, then an interpretation similar to Hoffman's would not be appropriate for the present data because the warm-up effect was attenuated only when the shocks were delivered with an intershock interval of 64 sec.

REFERENCES

Azrin, N. H., Urlich, R. E., Hutchinson, R. R., and Norman, D. G. Effect of shock-duration on shock-induced fighting. *Journal of the Experimental Analysis of Behavior*, 1964, **7**, 9-11.

Creer, T. L., Hitzing, E. W., and Schaeffer, R. W. Classical conditioning of reflexive fighting. *Psychonomic Science*, 1966, **4**, 89-90.

Daniel, W. J. An experimental note on the O'Kelley-Steckle reaction. *Journal of Comparative Psychology*, 1943, **35**, 267-268.

Farris, H. E., Gideon, B. E., and Ulrich, R. E. *Classical conditioning of aggression: a developmental study.* Paper read at the American Psychological Association meetings, San Francisco, 1968.

Gormezano, I. Classical conditioning. In J. B. Sidowski (Ed.), *Experimental methods and instrumentation in psychology*. New York: McGraw-Hill, 1966. Pp. 385-520.

Hoffman, H. S. The analysis of discriminated avoidance. In W. K. Honig (Ed.), *Operant behavior: areas of research and application*. New York: Appleton-Century-Crofts, 1966. Pp. 499-530.

O'Kelley, W. J. and Steckle, L. C. A note on long-enduring emotional responses in the rat. *Journal of Psychology*, 1939, **8**, 125-131.

Rescorla, R. A. Pavlovian Conditioning and its proper control procedures. *Psychological Review*, 1967, **74**, 71-80.

Thompson, T. and Sturm, T. Classical conditioning of aggressive display in Siamese fighting fish. *Journal of the Experimental Analysis of Behavior*, 1965, **8**, 397-403.

Ulrich, R. E. Unpublished study, 1962. Cited in Ulrich, R. E., Hutchinson, R. R., and Azrin, N. H. Pain-elicited aggression. *Psychological Record*, 1965, **15**, 111-126.

Ulrich, R. E. and Azrin, N. H. Reflexive fighting in response to aversive stimulation. *Journal of the Experimental Analysis of Behavior*, 1962, **5**, 511-520.

Vernon, W. and Ulrich, R. Classical conditioning of pain-elicited aggression. *Science*, 1966, **152**, 668-669.

Zeaman, D. and Smith, R. W. Review of some recent findings in human cardiac conditioning. In W. F. Prokasy, *Classical Conditioning*. New York: Appleton-Century-Crofts, 1965. Pp. 378-418.

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